Mainstream Media
2000 “应氏杯”世界电脑围棋锦标赛
2000 ING CUP WORLD COMPUTER GOE CHAMPIONSHIP
主办：应昌期围棋教育基金会
承办：贵阳市棋类协会
贵阳应氏围棋活动中心
(1985-2000)
5d win 1998
This is the first time that a computer program has defeated a human professional player in the full-sized game of Go, a feat previously thought to be at least a decade away.

What did AlphaGo do to beat the strongest human Go player?

Tobias Pfeiffer
@PragTob
pragtob.info

bitcrowd
Computational Challenge
Monte Carlo Method
What did we learn?
Go vs. Chess
Complex vs. Complicated
„While the Baroque rules of **chess could only have been created by humans**, the rules of **go** are so elegant, organic, and rigorously logical that **if intelligent life forms exist elsewhere in the universe, they almost certainly play go.**“

Edward Lasker (chess grandmaster)
Larger board

19x19 vs. 8x8
Almost every move is legal
Average branching factor:

250 vs 35
State Space Complexity:

$10^{171}$ vs $10^{47}$
Global impact of moves
Traditional Search
Monte Carlo Method
What is \( \pi \)?
How do you determine Pi?
Backpropagation
Perspective
Multi Armed Bandit
Multi Armed Bandit

Exploitation vs Exploration
\[ \frac{\text{wins}}{\text{visits}} + \text{explorationFactor} \sqrt{\frac{\ln(\text{totalVisits})}{\text{visits}}} \]
Generate a valid random move
Who has won?
General Game Playing
Anytime
Lazy
Neural Networks
Move Evaluation in Go Using Deep Convolutional Neural Networks

Chris J. Maddison
University of Toronto
cmaddis@cs.toronto.edu

Aja Huang\(^1\), Ilya Sutskever\(^2\), David Silver\(^1\)
Google DeepMind\(^1\), Google Brain\(^2\)
{ajahuang, ilyasu, davidsilver}@google.com

Abstract

The game of Go is more challenging than other board games, due to the difficulty of constructing a position or move evaluation function. In this paper we investigate whether deep convolutional networks can be used to directly represent and learn this knowledge. We train a large 12-layer convolutional neural network by supervised learning from a database of human professional games. The network correctly predicts the expert move in 55\% of positions, equalling the accuracy of a 6 dan human player. When the trained convolutional network was used di-
What does this even mean?
Neural Networks
Neural Networks
Weights
Bias/Threshold
Activation
Activation

5.2 \geq 4

2
-3
3.2
Activation
Training
Adjust parameters
Supervised Learning

Input

Expected Output
Backpropagation
Data set
Training data + test data
Verify
Deep Neural Networks
Local Receptive Field
Stride
Shared weights and biases
Multiple Feature maps/filters
Architecture

Input Features

12 layers with 64 - 192 filters

Output
Architecture

Input Features

12 layers with 64 - 192 filters

Output
Architecture

12 layers with 64 - 192 filters

Input Features → ... → Output
2.3 million parameters
630 million connections
Input Features

- Stone Colour \( \times 3 \)
- Liberties \( \times 4 \)
- Liberties after move played \( \times 6 \)
- Legal Move \( \times 1 \)
- Turns since \( \times 5 \)
- Capture Size \( \times 7 \)
- Ladder Move \( \times 1 \)
- KGS Rank \( \times 9 \)
Training on game data predicting the next move
55% Accuracy
Mostly beats GnuGo
Combined with MCTS in the Selection
Asynchronous GPU Power
Action Value
Prior Probability
Visit Count
Selection

- Action Value
- Prior Probability
- Visit Count
Action Value + Bonuses

0.8

1.2  0.5  1.1  0.9
Prior Probability
Evalutation
Rollout
3 Strengths of AlphaGo

Human Instinct
Reading Capability
Positional Judgement
Policy Network
Search
Value Network
Most Important Strength

Human Instinct

Reading Capability

Policy Network

Search

Positional Judgement

Value Network
More Natural
Lee Sedol match
So when AlphaGo plays a slack looking move, we may regard it as a mistake, but perhaps it should more accurately be viewed as a declaration of victory?

An Younggil 8p
Game 2
What can we learn?
Making **faster**

vs

Doing **less** of **x**
Benchmark everything
Solving problems the human way
vs
Solving problems the computer way
Don’t blindly dismiss approaches as infeasible
One Approach vs Combination of Approaches
Joy of Creation
PragTob/RubyKon

PragTob/RubyKon

Make a move in the form XY, e.g. A19, D7 as the labels indicate!

White's turn to move!
Rubykon is thinking...

Black's turn to move!

White's turn to move!
Rubykon is thinking...

Black's turn to move!

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Michi --- Minimalistic Go MCTS Engine

Michi aims to be a minimalistic but full-fledged Computer Go program based on state-of-art methods (Monte Carlo Tree Search) and written in Python. Our goal is to make it easier for new people to enter the domain of Computer Go, peek under the hood of a "real" playing engine and be able to learn by
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@PragTob
pragtob.info
Sources


- https://www.youtube.com/watch?v=LX8KnI0g0LE&index=9&list=WL
Photo Credit

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